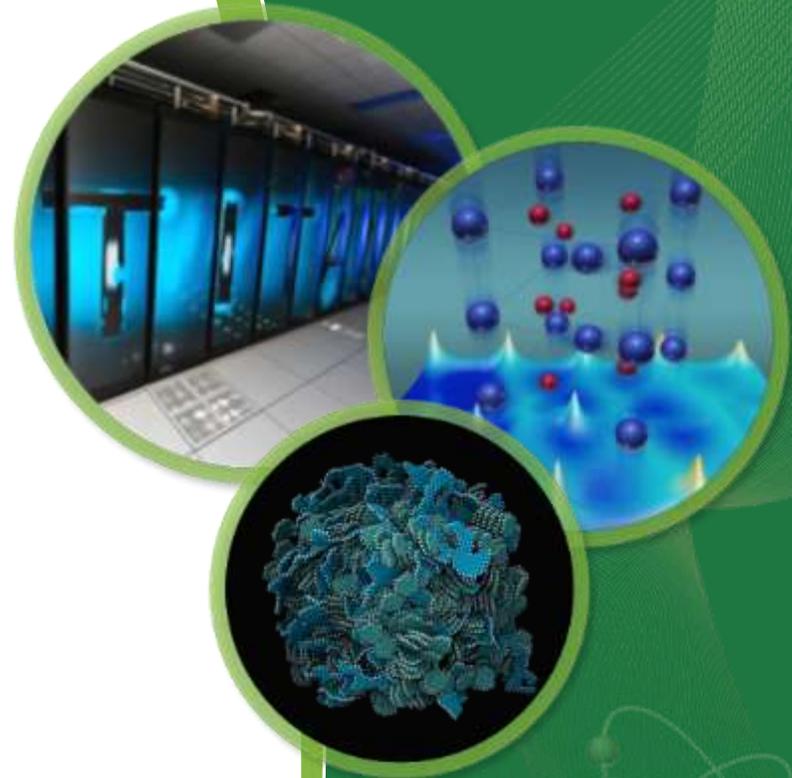


Alarm System Update based on Apache Kafka

June 2018

Kay Kasemir

Evan Smith

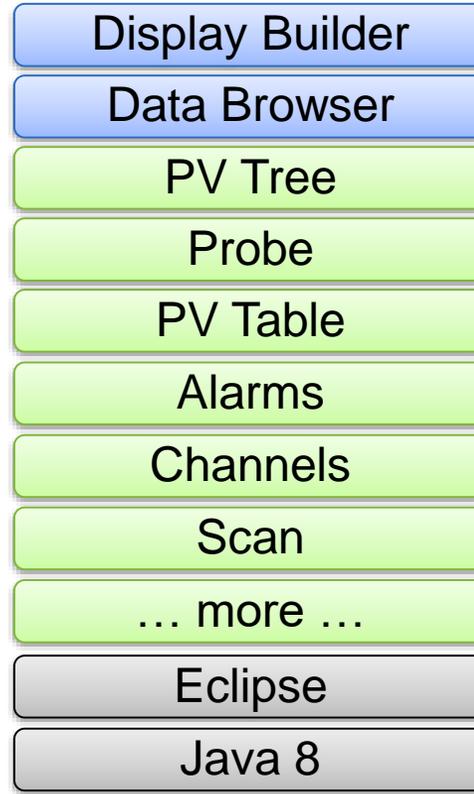


Evolution of CS-Studio

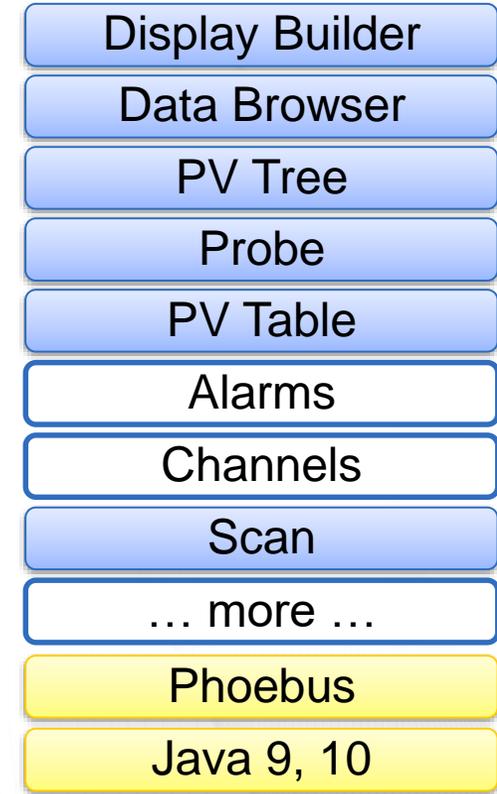
JavaFX SWT



Since ~2010:
Operational at several sites



Since ~2016:
SNS beam lines,
planned for ESS



End of 2018 Goal:
Some SNS beam lines

Alarm System

Alarm Server

- Monitor PVs
- Track alarms, acknowledgement

Alarm UI

- Configure (add PVs, guidance, links to displays)
- Show current state
- Acknowledge alarms
- Open guidance, related displays, email, log, ..

The screenshot displays the Alarm System UI with several panels:

- Alarm Area Panel:** A grid of buttons representing different areas, such as BeamPermit, CF, HPRF_PLC_Check, RF, PPS, Tunnels, Water_Pump, IonSource&LEBT, RFQ, MEBT, DTL, CCL, SCL, HEBT, RID, Ring, RTBT, Target, Test, Instrument Hall, CER, Vacuum, CHL, Operations, HVCM, RF Transmitters, Momentum Dump, Test HVCM, In Test Facility (Test RF Transmitter), Force Test Stand, Klystron Gallery, BT Service Build, and Test Service Build.
- Alarm Tree:** A hierarchical tree view showing the structure of the alarm system, including areas like BeamPermit, CF, HPRF_PLC_Check, RF, PPS, Tunnels, Water_Pump, IonSource&LEBT, RFQ, MEBT, DTL, CCL, SCL, HEBT, RID, Ring (MAJOR/HIGH_ALARM), RTBT, Target, Test, and Instrument Hall.
- Alarm Table [CCR]:** A table showing current and acknowledged alarms. The 'Current Alarms (2)' section includes:

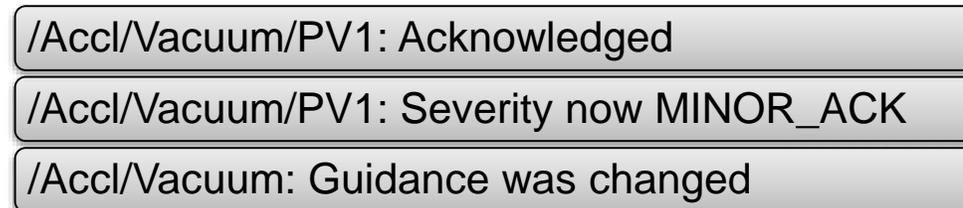
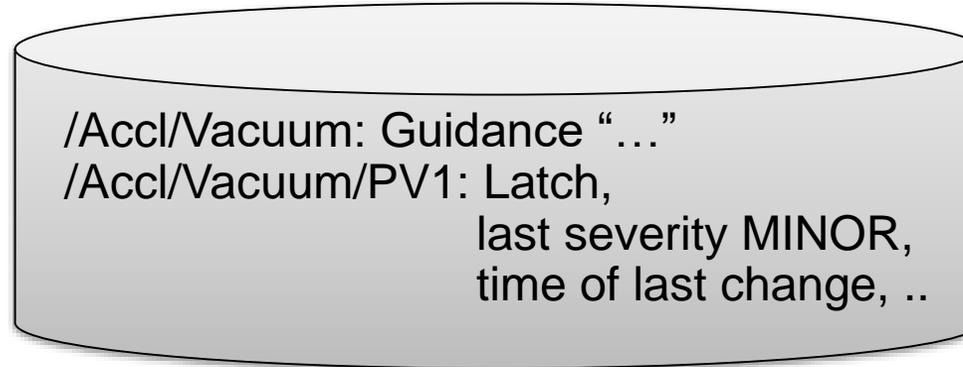
PV	Description	Alarm Time	Current Sever	Current Status
ICS_Opr:RFQ:VacuumAlarm	Attention. R F Q vacuum alarm	2018-05-30 08:45:40	OK	NO_ALARM
CF_RN_DIWS_AIT4601B:Rk	Hebbit Ring RTBT Magnets DI water polishing loop	2018-05-30 03:28:11	MAJOR	HIGH_ALARM

The 'Acknowledged Alarms (13)' section includes:

PV	Description	Alarm Time	Current Sever	Current Status
Test_LLRF:Cav_RFQ1:OK	Attention. Process Variable	2018-05-17 01:59:54	MAJOR	STATE_ALARM
Test_HPRF:Xmtr101:RP_Fit	BTF rf transmitter fault	2018-05-25 10:24:11	MAJOR	STATE_ALARM
Test_HPRF:PPSwitch_RFQ:Sum	Attention. Attention. BTF RFQ PPS is inhibited	2018-05-23 15:36:30	MAJOR	HIHI_ALARM
SpRFQ_Cool:TestStand:WaterLea	Attention. B T F Water Leak Alarm	2018-05-29 12:13:48	INVALID	READ_ALARM

Current Architecture

- RDB
 - Configuration
 - Snapshot of last known state
- JMS
 - Acknowledge requests
 - State updates
 - Notification of configuration updates



Alarms: From RDB/JMS to Kafka

Clients need

- Config and initial state: RDB
- state updates: JMS

→ Do all that in Kafka?!

- Topic ‘Accelerator’ for configuration

```
/Accl/Vacuum: {"guidance": ...}
```

```
/Accl/Vacuum/PV1: {"latch":true, ...}
```

- Topic ‘AcceleratorState’ for state

```
/Accl/Vacuum/PV1: {"severity":"MINOR", ...}
```

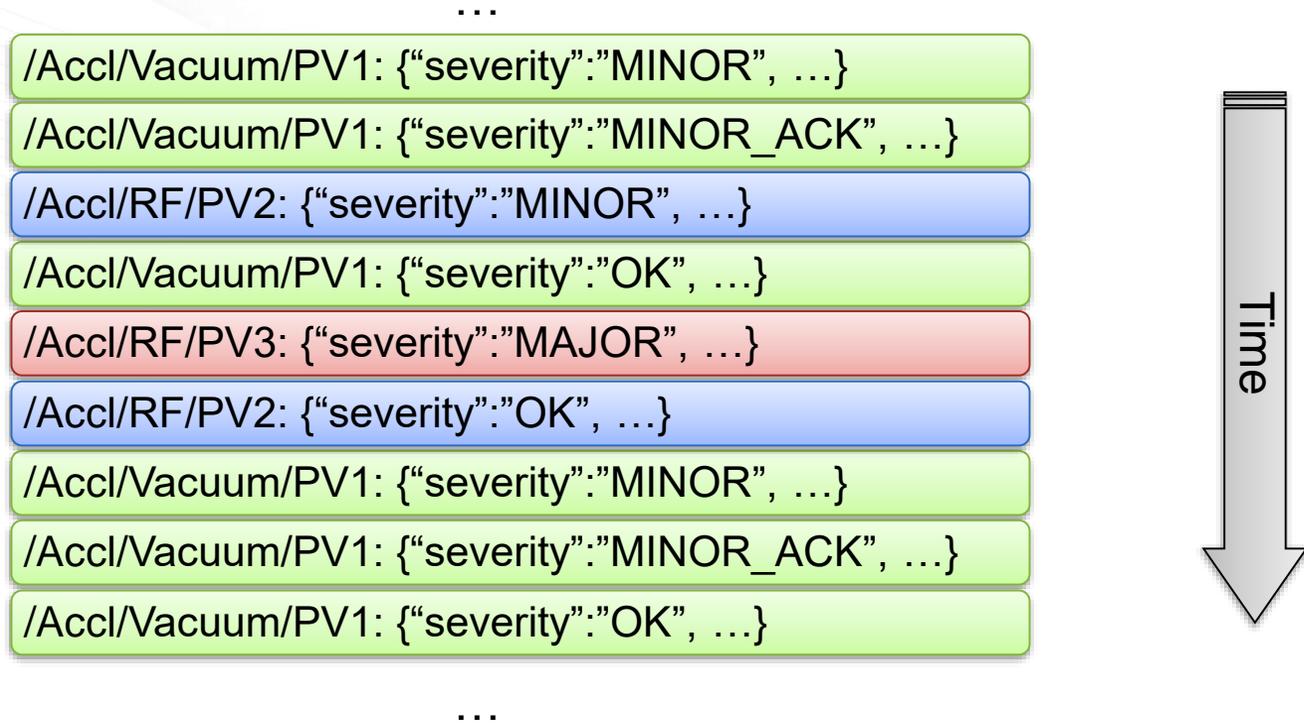
```
/Accl/Vacuum/PV1: {"severity":"MINOR_ACK", ...}
```

```
/Accl/Vacuum: Guidance "..."  
/Accl/Vacuum/PV1: Latch,  
last severity MINOR,  
time of last change, ..
```

```
/Accl/Vacuum/PV1: Severity now MINOR_ACK
```

Kafka stream for Alarms, 'AcceleratorState'

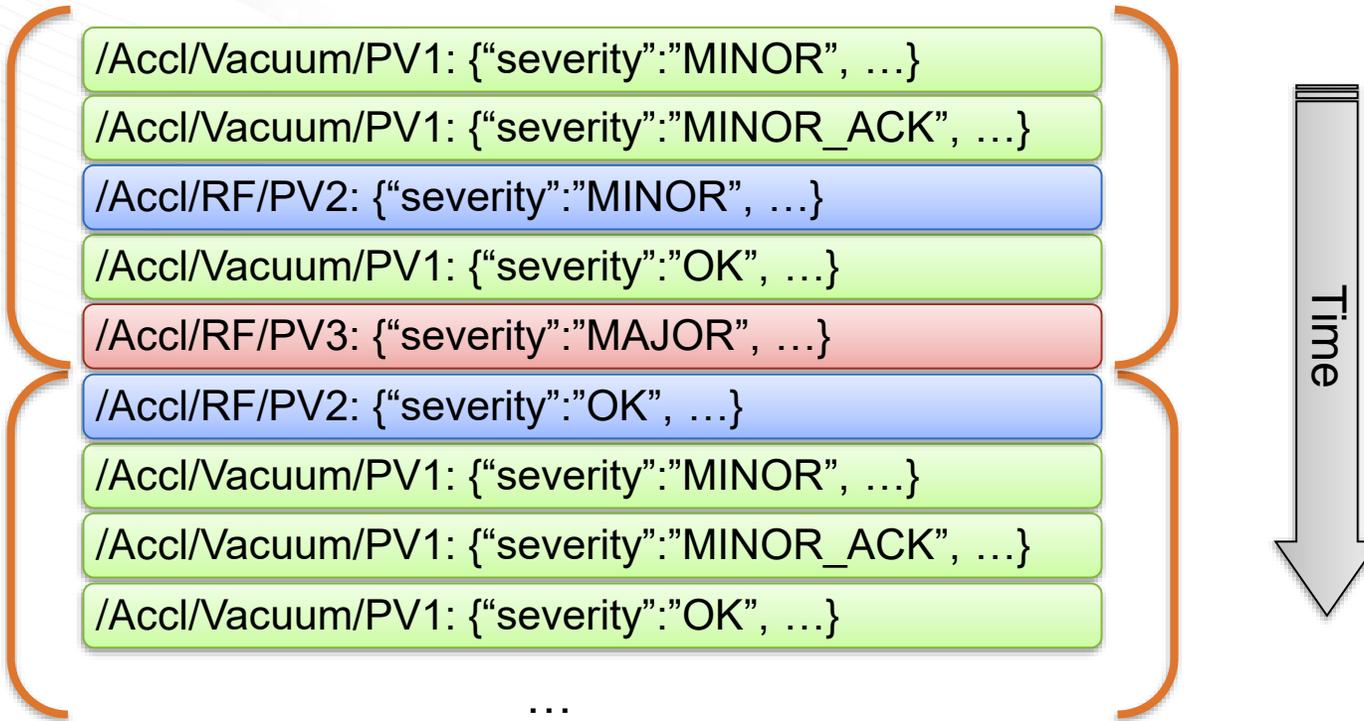
- From beginning of time, never ending



Clients tend to only need the most recent state for each item, followed by updates

Kafka Storage of 'AcceleratorState'...

New 'segment', e.g. every 10 seconds..

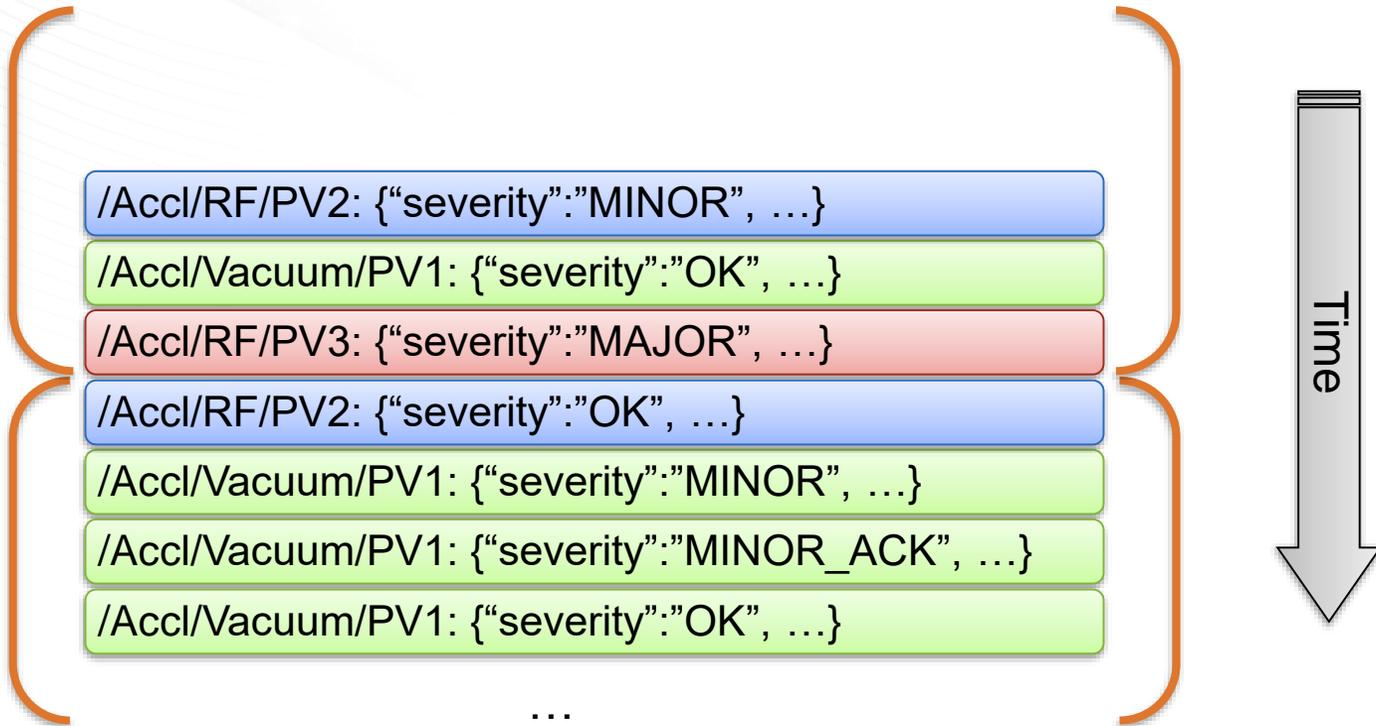


Simply delete older segments?

Then state of PV3 is lost..

'Compacted' Kafka 'AcceleratorState'

Keeping *single* older segment w/ *last value* for each item



New clients get at least the most recent state for each item, maybe a few more, followed by updates

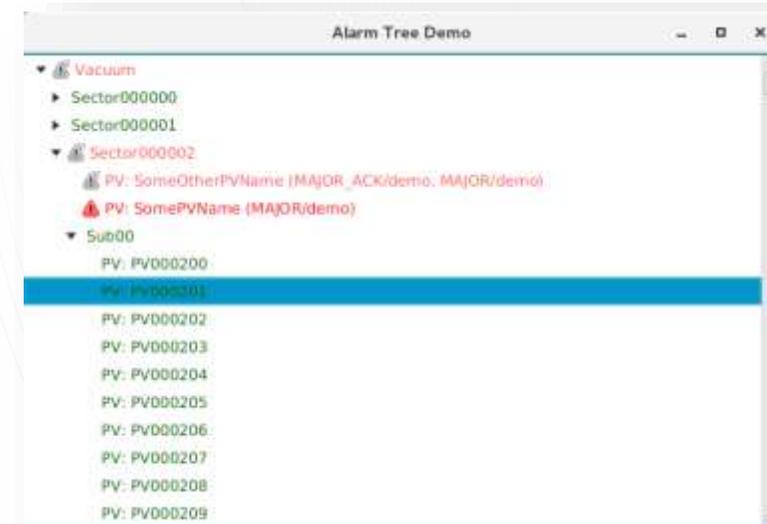
Initial Tests

2010 Test (PosgreSQL, JMS)

- Load hierarchy with **50000** PVs into RDB
 - **5 minutes**
- Show config in new Alarm Tree
 - **Nothing** shown until all loaded after **30** seconds
- Handle Alarm Updates
 - **10** per second

2018 Test (Kafka)

- **100000** PVs into Kafka
 - **3 seconds**
 - **Shows** growing tree for **10** seconds
 - **500** per second



State of Development

- Functional
 - Alarm Server
 - Import/Export of XML-based configuration
 - Same format as before
 - Alarm Tree
 - Configure, monitor, acknowledge, ..
 - Alarm Table
 - Primary operator view of current alarms
 - Area Panel
 - For cross-the-room status check
- To Do
 - Annunciator
 - Authentication for changes



Further Ideas for kafka[®] - based Alarm System

- Stream 'compacted' alarm topics into
 - Non-compacted Kafka Topics:
Long-term history
 - RDB, MongoDB, ElasticSearch:
Alternate long-term history, existing tools to analyze

For what it's worth:

ESS uses Kafka to stream

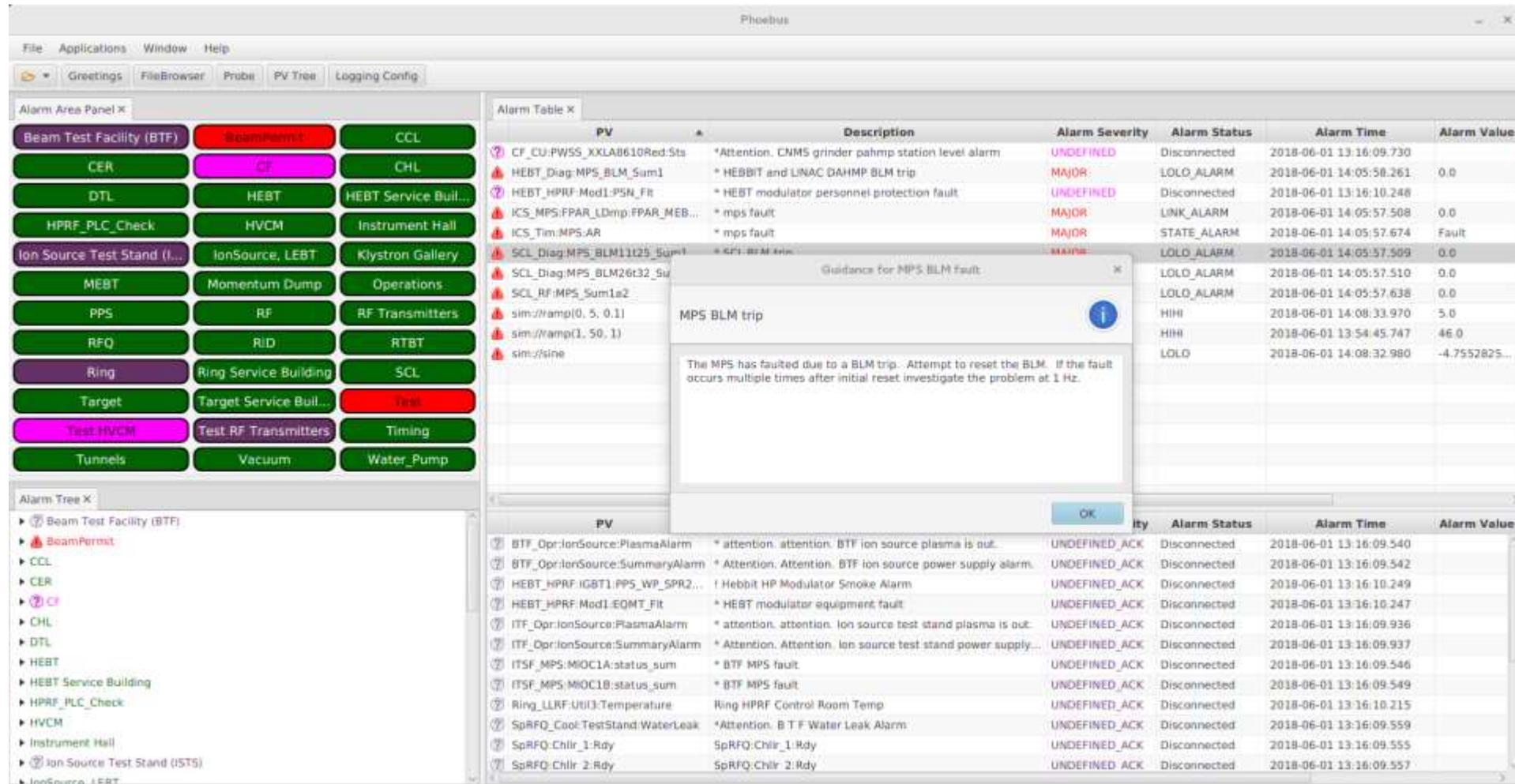
EPICS PVs & Instrument data,

<http://accelconf.web.cern.ch/AccelConf/icaleps2017/papers/tupha177.pdf>

Alarm System Update for Phoebus

~~RDB & JMS~~ → 

- Same XML import/export
- Similar UI
- Performance headroom



The screenshot displays the Phoebus Alarm System interface. On the left, there is a grid of colored buttons representing different system areas like 'Beam Test Facility (BTF)', 'CER', 'DTL', etc. Below this is an 'Alarm Tree X' showing a hierarchical view of the alarm system. The main area is an 'Alarm Table X' with columns for PV, Description, Alarm Severity, Alarm Status, Alarm Time, and Alarm Value. A dialog box titled 'Guidance for MPS BLM fault' is open, providing instructions for handling an MPS BLM trip. The table shows several active alarms, including 'CF_CU:PWSS_XXLAB610Red.Sts' and 'HEBT_Diag:MPS_BLM_Sum1'.

PV	Description	Alarm Severity	Alarm Status	Alarm Time	Alarm Value
CF_CU:PWSS_XXLAB610Red.Sts	*Attention. CNMS grinder pahmp station level alarm	UNDEFINED	Disconnected	2018-06-01 13:16:09.730	
HEBT_Diag:MPS_BLM_Sum1	* HEBBIT and LINAC DAHMP BLM trip	MAJOR	LOLO_ALARM	2018-06-01 14:05:58.261	0.0
HEBT_HPRF:Mod1:PSN_Fit	* HEBT modulator personnel protection fault	UNDEFINED	Disconnected	2018-06-01 13:16:10.248	
ICS_MPS:FPAR_LDmp:FPAR_MEB...	* mps fault	MAJOR	LINK_ALARM	2018-06-01 14:05:57.508	0.0
ICS_Tim:MPS:AR	* mps fault	MAJOR	STATE_ALARM	2018-06-01 14:05:57.674	Fault
SCL_Diag:MPS_BLM1125_Sum1	* MPS BLM trip	MAJOR	LOLO_ALARM	2018-06-01 14:05:57.509	0.0
SCL_Diag:MPS_BLM26t32_Su...			LOLO_ALARM	2018-06-01 14:05:57.510	0.0
SCL_RF:MPS_Sum1a2			LOLO_ALARM	2018-06-01 14:05:57.638	0.0
sim://amp(0, 5, 0.1)	MPS BLM trip		HIHI	2018-06-01 14:08:33.970	5.0
sim://amp(1, 50, 1)			HIHI	2018-06-01 13:54:45.747	46.0
sim://sine			LOLO	2018-06-01 14:08:32.980	-4.7552825...

Other Changes

- Server now 'maximizes' severity of all nodes up to root
 - Used to be in client
 - Has to be in server to support 'sevr_pv'
- A little more traffic, but
 - simpler client code
 - more information for reports, statistics, dashboards

Quirks (not show stoppers)

- Deleting and then re-creating a topic to “start over” causes log cleaner to quit. Need to restart Kafka.

- “Delete” alarm tree node..
means adding a null entry.
New clients often see both messages,
i.e. add and soon delete the entry.

```
/Accl/Vacuum/PV1: {"latch:true, ...}
```

```
/Accl/Vacuum/PV1: null
```

Full cleanup means starting over:
Export data,
recreate topic (requires Kafka restart),
import data.